Cultivating Knowledge: Agriculture Across the Disciplines seminar series

Agriculture and Genetics

Ketema Daba, PhD

Research Officer, Soybean Breeding

Crop Development Centre, Department of Plant Sciences
College of Agriculture and Bioresources

CROP DEVELOPMENT CENTRE
USASK

Agriculture and Global Population

- World population increase, 9.7 billion in 2050
- Substantial increase in food demand
- Filling a food gap between crop produced today vs demand in 2050
- Expansion of alternative crops
- Controlling the GHG emitted by agricultural activities

Increase in Food Production

- Soybean (*Glycine max* L. (Merr)) is one of the key crops that would play an important role in food security and sustainability worldwide
- One of the major food, feed crops of the world
- Protein content: (about 40%), Oil content: (about 20%)
- Soil fertility through symbiotic nitrogen fixing rhizobia
  - Reduces the requirement for nitrogen fertilizer
  - Lowers carbon footprint of the cropping system
- Breaking the disease cycle: Rotation

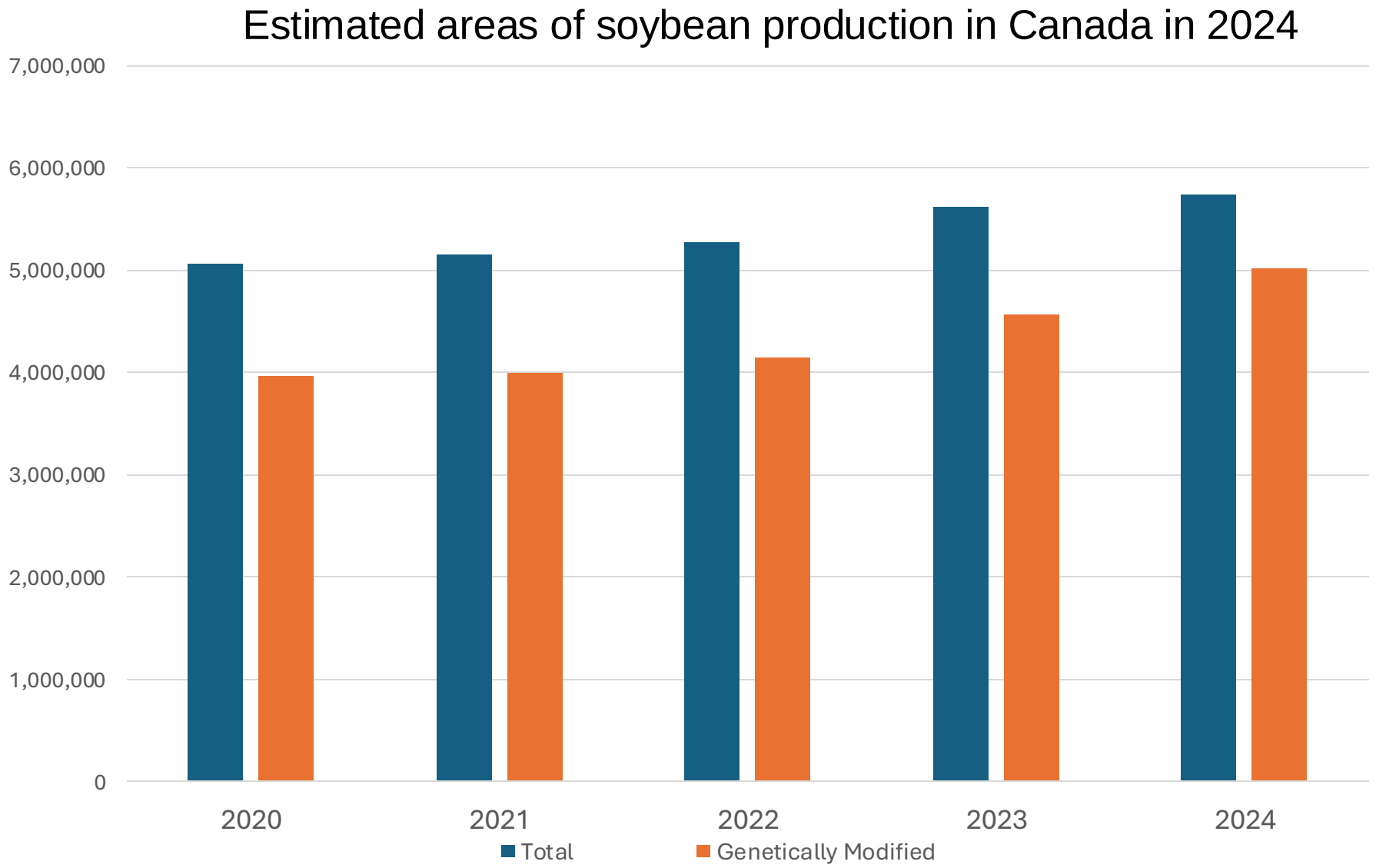
Increase in Food Production

- Wide range of genetic variability in soybean germplasm
- Wide range of geographical adaptation
- Unique chemical composition of the seed
- Good nutritional value
- Functional health benefits
- Industrial applications

Global Soybean Production: 2023/2024

Market	% of Global Production	Total Production (2023/2024, Million Metric Tons)
Brazil	39%	153
United States	29%	113.34
Argentina	12%	48.1
China	5%	20.84
India	3%	11.88
Paraguay	3%	11
Canada	2%	6.98
Russia	2%	6.8
Ukraine	1%	5.2
Bolivia	0.92%	3.65

https://fas.usda.gov/



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Food and Feed Uses

- Feed
  - Soy meal for animal feed for livestock, poultry production and fishery industry
- Food purpose
  - Fermented
    - Soy sauce
    - Natto
    - Miso
  - Non-fermented
    - Oil
    - Milk
    - Tofu
    - Flour foods

Maturity Group in Soybean

- Thirteen MGs
- Soybeans are sensitive to photoperiod
- Varieties have been bred to respond to photoperiod; referred as Maturity Groups
- Indeterminate flowering: flowers for up to six weeks
- Delayed flowering increases height and vegetative growth but less yield benefit
- Early flowering due to a combination of temperature and photoperiod effect helps the genotype to enter the reproductive stages earlier in the growing season leading to higher yield

Saskatchewan Agriculture

- World’s leading producer and exporter of many crops
- The most important global pulse crops: field pea, lentil, chickpea, common bean and faba bean
- Canadian prairie agriculture additional requires reliable legume crop
- Production of major pulse and other crops in the region is challenged by disease
- Soybean is a relatively disease free, nitrogen fixing option that can fit well into cereal/canola crop rotations

Soybean Breeding at CDC

- Soybean is a major crop of eastern Canada and eastern Manitoba
- Relatively new to the Canadian prairie region west of the Manitoba escarpment
- Limited expansion due to lack of high yielding, very early maturing cultivars
- Lower in protein concentration than soybean production in eastern Canada and the USA mid-west.
- Important to improve the sustainability of soybean as a cropping option in western Canada
- Developing soybean varieties specifically suited to Canadian prairie growing conditions
- Target to breeding for MGs 00 and 000

Soybean Breeding at CDC

2013-2018

- Pilot project breeding program at the CDC
- Early generation populations (F2-F3) were supplied by Cober (AAFC-Ottawa) for selection by Warkentin under SK conditions

2018-Present

- Crossing has been initiated at CDC
- The crossing program has been proceeding successfully
- In the 2024 season, promising lines arising from CDC crosses were evaluated in F1-F7 generation nurseries/trials

Soybean Breeding Scheme at CDC

Activity	Description
• 10-15 new germplasm introduced	
• 60-80 new crosses	
• The F1 of the 80 crosses evaluated	
• 80 F2s populations evaluated	Winter nursery at Costa Rica in 2024/25
• 4000 F2 derived F3 microplots evaluated	F3 Microplots
• 800 F4 lines evaluated	Preliminary Yield Trial
• 96 F5 lines evaluated	Advanced Yield Trial
• 24 F6 lines evaluated	Elite Yield Trial
• 4 F7-F8 lines evaluated	Regional Variety Trial
• Variety release	

Soybean Crossing at CDC

F1 plants in the College of AgBio greenhouse

Nurseries

Yield Trials

Segregating population at Investigation Field
Picture taken on September 5, 2024

Yield trials at Campus Field
Picture was taken on September 16, 2024

Germplasm Sources

- National and international germplasm exchange
  - PGR Saskatoon
  - USDA soybean Germplasm Resources Information Network (GRIN) database
  - AAFC Ottawa, CEROM
- MTA with public and private breeding companies
  - University of Guelph, Ridgetown Campus
  - North Dakota State University
  - University of Minnesota
  - Iowa State University
  - Prograin
  - Protealis, Belgium
- Use of elite lines in our breeding program

Breeding and Yield

- Major soybean breeding objectives are grain yield, maturity, protein, pest resistance
- Major yield components
  - numbers of nodes/plant
  - number of pods/node
  - number of seeds/pod and
  - seed size/weight
- Adapting soybean to new production environments requires improvement in yield potential for cultivars

Protein Concentration

- Soybean seed protein is often lower in western compared to eastern Canada
- Increases in the seed protein concentration of soybean would improve the value of the crop
- Yield and protein content are negatively correlated
- With an increase of seed protein by 1%, seed yield were reduced by 45.3 kg ha^{-1} in OT, 53.1 kg ha^{-1} in the MB, and 78.4 kg ha^{-1} in SK
- Improve yield with other key traits (protein) when they are unfavorably correlated
- Identify genotypes that produce superior yield and protein content

Breeding and Adaptation of Soybean

- Soybean production continues because of the increasing demand for soybeans and soybean products
- Historical improvement: lodging resistance, shattering, seed size, yield capacity, disease and stress tolerance
- Breeding to constantly adapt new varieties to new environmental conditions and management strategies
- Success in breeding depends on:
  - Germplasm availability
  - Genetic variation
  - Selection strategies
  - Resources: public and private crop-breeding budgets

GENOMIC APPLICATIONS PARTNERSHIP PROGRAM (GAPP)

2020 to 2023

- Lead by Dr. François Belzile,University of Laval
- Development and implementation of a toolkit for genomics-assisted breeding in soybean
- A genomic prediction tool to guide soybean breeders in the choice of the most promising crosses to make and characterize
- Breeders' provide historical phenotypic data on the soybean lines to develop the training sets

  These TSs were used to derive genomics-informed predictions on the crosses that promise to give rise to the best progeny
- Used the model to select parental lines in 2024 soybean crossing block

Future Crop Breeding

- Explosion of field of soybean research over the past decade
- Future yield growth is essential to keep up with demand
- Conventional breeding, the selection of best-performing crops, accounted for half of historical crop yield gains
- New advances in molecular technologies offer great promise for additional yield gains
- Yield increase is anticipated due to:
  - Growing demand
  - Availability of adequate genetic variation
  - Growing field of biotechnology and molecular breeding schemes

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SASKATCHEWAN pulse Growers

Saskatchewan

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GenomeCanada

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Thank you!